Where's the root:

A study of root distribution in Douglas-fir

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Objectives

(continued from other poster)

- To develop allometric relationships between root dimensions and volume from harvested root data in order to obtain predictable relationships for future studies of roots.

Figure 1. Photo showing the two trees before excavation with the vegetation survey grid present. The larger Douglas-fir tree is on the right.

Site Description

The site used for study was a 23-year-old stand planted in 1977 with Douglas-fir (*Pseudotsuga menzesii*) following clearcutting of an old-growth Douglas-fir/western hemlock (*Tsuga heterophylla*) forest. The site was located in the Wind River Experimental Forest of the Gifford Pinchot National Forest in southwestern Washington. A legacy of this old growth stand can be readily seen in the stumps and logs. Not seen is the underground root structure left by these trees.

The physical characteristics of the site include a 10% slope, a tephra soil and long, dry summers. The soil is a deep, well-weathered tephra, including a rich organic litter layer roughly 7-10 cm in depth, which overlies a thin layer of ash. The summers are characterized by long dry periods for three to four months leading to potentially severe drought conditions, whereas the winters are extremely wet. Total annual precipitation is above 2500 mm.

The characteristic vegetation of this site included the dominant Douglas-firs, sub-dominant western hemlocks and vine maple (*Acer circinatum*) with a few Pacific silver firs (*Abies amabilis*). (**Figure 2**) The understory vegetation was predominantly salal (*Gaultheria shallon*), bracken fern (*Pteridium aquilinum pubescens*), Oregon grape (*Mahonia nervosa*) and oval-leafed huckleberry (*Vaccinium ovalifolium*). There were 25 different species in the understory.

The two study trees were a dominant and a co-dominant Douglas-fir. The larger tree was 22 years old, 24-cm in diameter at breast height and was approximately 4.5 m uphill from the smaller tree. The smaller tree was 19 years old and 15.8-cm in diameter. A large residual log separated the two trees.

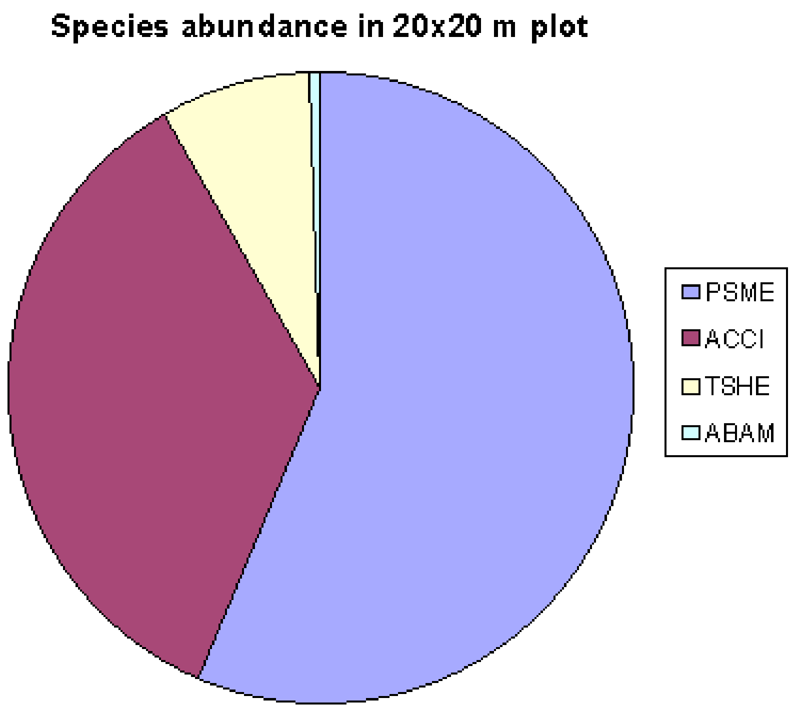


Figure 2. Pie graph showing tree species abundance in the 20x20m plot surrounding the two specimen Douglas-firs. Four species are included: *P. menzesii* (PSME), *A. circinatum* (ACCI), *T. heterophylla* (TSHE), *and A. amabilis* (ABAM).

Methods

Site Preparation:

A 2-meter deep soil pit was dug to describe the soil and to get an idea of root distribution. To inventory the site, a 20x20m plot was surveyed and within each 5 x 5 m sub-plot, tree species, breast height diameters and canopy extent were measured for all trees reaching breast height. Stumps and large logs were also located on this map. A 10x5m sub-plot encompassing the two study trees was surveyed and all understory vegetation species and their location were mapped. Before using the Ground Penetrating Radar (GPR), the understory vegetation and low branches from trees were completely removed from the plot. The GPR needs a relatively smooth surface to slide across. Prior to starting excavation with the Air Spade, the two Douglas-fir trees were felled. The needles of the larger tree were all collected for measurement of leaf area by another investigator.

Harvesting Roots:

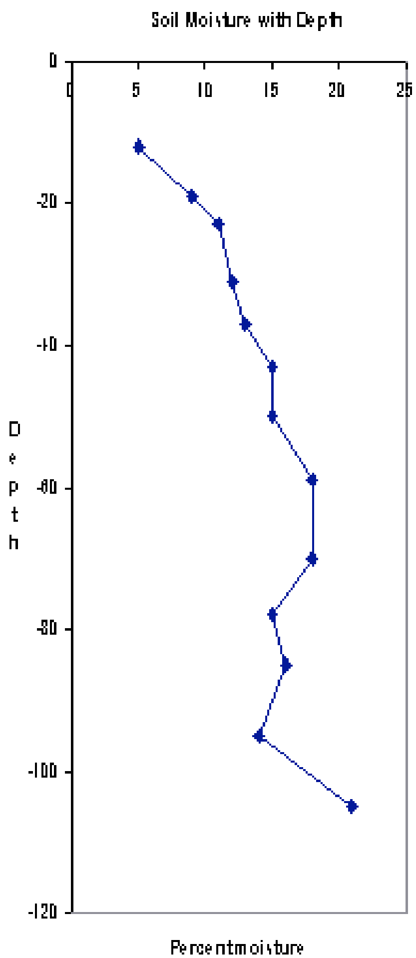
After excavating and mapping the roots, all the small (1mm-10mm) and medium (10mm–20mm) sized roots were cut from the larger roots and the bole of the two trees. These roots were stored according to which quadrant they came from.

Analysis:

Harvested roots were all measured for length, diameter and volume. Roots were washed using a screen to prevent loss. Length was measured with a tape measure. Diameters were taken using calipers at three locations on each root: the base, a middle point, and the tip. Notations were made of cut or broken roots. Volume was measured by displacement of water in graduated cylinders for individual roots. Not all roots were measured individually. Roots were separated into size classes for each quadrant and five individual roots were chosen randomly from each size class. The rest of the roots were measured together as a bulk sample. Bulk samples were measured using a modified bucket with a spout to drain water into a graduated cylinder.

Figures 3a and 3b. Figure 3a shows the authors harvesting roots from the upper layers of roots on the larger Douglas-fir. Figure 3b shows the difference of roots without small roots (the left), and roots with small roots(the right). This is the smaller of the two Douglas-fir trees excavated to 60 cm below ground level.

Soil Profile



Soil Characteristics

← Organic layer - packed with roots

←Thin layer of volcanic ash

←Sandy loam - pebbly texture

←Gravel layer (rounded rocks and cobbles)

←Silty loam - blocky with a finer texture

←Wetter clay-like silty loam - plate-like

Analysis

The analysis of the data collected from the harvested roots investigated relationships between basal diameter and length of a root and between basal diameter and volume of a root.

For diameter verses length, a logarithmic function provided the best fit (**Figure 4**). For 1 to 20 mm basal diameter, there appears to be a maximum length of root. For roots with broken or cut ends, predictions were made on their adjusted lengths based on average lengths of each size class. The average lengths were calculated from all of the complete roots in each size class. Size classes were determined by basal diameter. The adjusted lengths lie above the maximum length line, indicating that either the maximum length line is too conservative or this adjustment process resulted in error.

For diameter verses displacement (**Figure 5**), an exponential function gave the best fit. The data in this figure are all of the roots that had individual displacement data taken. Although it is clear that for the larger size classes there are outliers; this can be attributed to broken and cut roots.

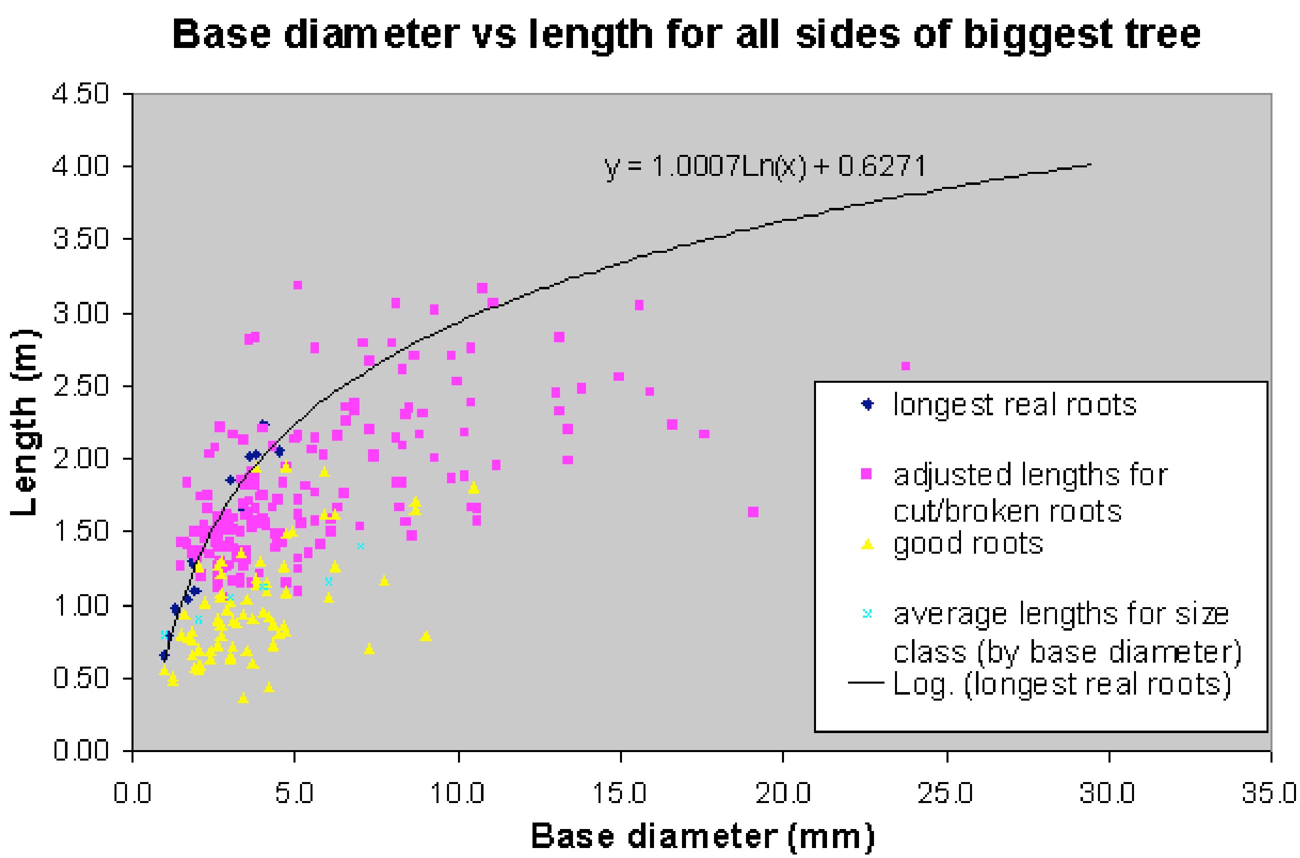


Figure 4. Basal diameter verses length for the larger Douglas-fir tree's harvested roots.

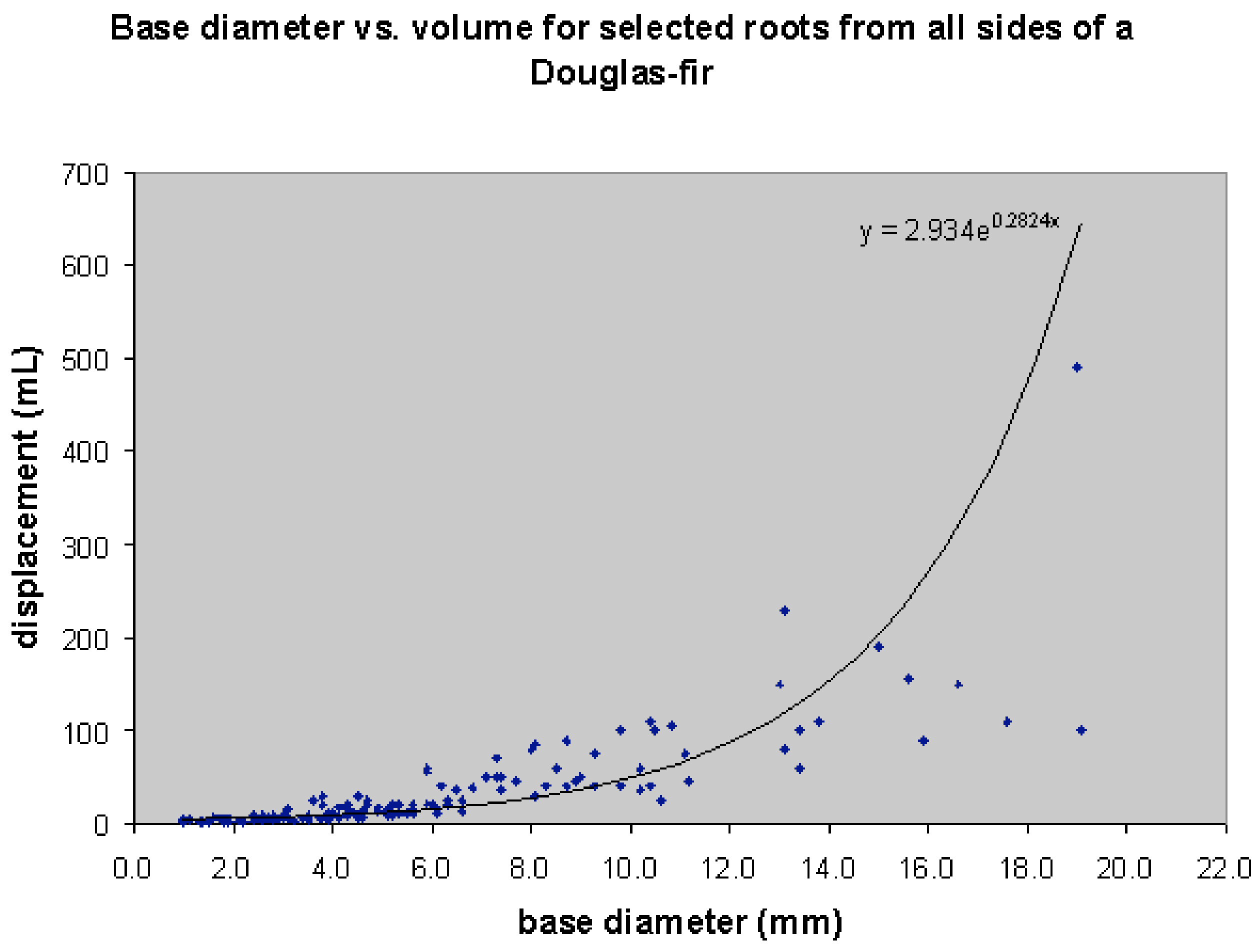


Figure 5. Basal diameter verses displacement for the same tree's harvested roots.

Conclusions

Although our data only explore a small fraction of the roots that were eventually excavated, allometric relationships were noted between basal diameter and either length or root volume. These relationships might enable one to estimate root lengths or volumes in a given region of the soil without major excavation. Our inability to avoid root damage with the air spade, the low taper on roots (versus branches and the stem), and our inability to know where roots are coming from or going without wider excavation, make such extrapolations risky.

For the Future

The next steps in this study will be to measure biomass of all the harvested roots, including roots for which we have information on displacement, length and diameter. The goal will be to eventually find a value for total biomass for the roots of the big tree. Biomass values will be compared to volume and dimensions of the roots to find additional allometric relationships plus to know the quantity of belowground biomass.

For the mapping portion of the project, attempts at making a three-dimensional map will continue. Possibilities include using laser technology to collect information in three dimensions and using a CAD computer program to make a digital map.

New improvements to the methods are being considered for the GPR, mapping and harvesting of the roots.

In the future, it would be good to repeat this study with more trees of the same age as well as a range of ages leading up to and including an old-growth forest. More information collected on roots will continue to help the understanding of the carbon, nutrient and water cycles in forests, including old growth forests.

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